VERIFICATION

The undersigned, of the below address, hereby certifies that he/she well knows both the English and Japanese languages, and that the attached is an accurate English translation of the Japanese Patent application filed on April 5, 2002 under No. P2002-103881.

The undersigned declares further that all statements made herein of his/her own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

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Date of Application: April 5, 2002

Application Number: Japanese Patent Application No2002-103881

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Commissioner,

Patent Office (Seal)

(Document Name)Patent Application

(Reference Number) 2001－0200

(Presentation Date) April 5, 2001

(Directly) Commissioner of the Patent Office

(IPC) H05G 1／30

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(Official Fee)

(Pre-Paid Master Note Number) 014708

(Amount to be paid) 21000

(Lists of the Article to be presented)

(Name of Article) Specification 1

(Name of Article) Drawing 1

(Name of Article) Abstract 1

(Proof Reading) Required

[Document Name] Specification

[Title of the Invention]

X-RAY TUBE CONTROL APPARATUS AND X-RAY TUBE CONTROL METHOD

[Claims]

[Claim 1]

An X-ray tube control apparatus which remotely controls an X-ray tube, comprising:

first storage means which stores a plurality of warming-up programs for warming up said X-ray tube to a maximum tube voltage, according to the maximum tube voltage values;

first extraction means which extracts one from said plurality of warming-up programs stored in said first storage means which corresponds to the maximum tube voltage value after being changed at that time the maximum tube voltage value of said X-ray tube is changed; and

first rewriting means which rewrites a warming-up program, stored in a memory section in a control apparatus that controls an operation of said X-ray tube, with said warming-up program extracted by said first extraction means via a telecommunications line.

[Claim 2]

An X-ray tube control apparatus which remotely

controls an X-ray tube, comprising:

second storage means which stores a plurality of limit tube voltage control programs for stopping application of a tube voltage with a limit tube voltage value corresponding to a maximum tube voltage value of said X-ray tube as a threshold, according to the maximum tube voltage values;

second extraction means which extracts said limit tube voltage control program from said plurality of limit tube voltage control programs stored in said second storage means which sets a limit tube voltage value corresponding to the maximum tube voltage value after being changed as a threshold at that time the maximum tube voltage value of said X-ray tube is changed; and

second rewriting means which rewrites a limit tube voltage control program, stored in a memory section in a control apparatus that controls an operation of said X-ray tube, with said limit tube voltage control program extracted by said second extraction means via a telecommunications line.

[Claim 3]

An X-ray tube control apparatus which remotely controls an X-ray tube, comprising:

third storage means which stores a plurality of

limit tube current control programs for stopping application of a tube voltage with a limit tube current value corresponding to a maximum tube voltage value of said X-ray tube as a threshold, according to the maximum tube voltage values;

third extraction means which extracts said limit tube current control program from said plurality of limit tube current control programs stored in said third storage means which sets a limit tube current value corresponding to the maximum tube voltage value after being changed as a threshold at that time the maximum tube voltage value of said X-ray tube is changed; and

third rewriting means which rewrites a limit tube current control program, stored in a memory section in a control apparatus that controls an operation of said X-ray tube, with said limit tube current control program extracted by said third extraction means via a telecommunications line.

[Claim 4]

An X-ray tube control apparatus which remotely controls an X-ray tube, comprising:

fourth storage means which stores a plurality of focus lens control programs for controlling a focus lens in such a way as to minimize a focal point when an electron beam hits a target of said X-ray tube with a maximum tube

voltage applied to the target, according to the maximum tube voltage values;

fourth extraction means which extracts said focus lens control program from said plurality of focus lens control programs stored in said fourth storage means which corresponds to the maximum tube voltage value after being changed at that time the maximum tube voltage value of said X-ray tube is changed; and

fourth rewriting means which rewrites a focus lens control program, stored in a memory section in a control apparatus that controls an operation of said X-ray tube, with said focus lens control program extracted by said fourth extraction means via a telecommunications line.

[Claim 5]

An X-ray tube control method which remotely controls an X-ray tube with an X-ray tube control apparatus,

wherein a plurality of warming-up programs for warming up said X-ray tube to a maximum tube voltage are stored in first storage means of said X-ray tube control apparatus beforehand according to the maximum tube voltage values, and comprising:

a first extraction step at which first extraction means of said X-ray tube control apparatus extracts one from said plurality of warming-up programs stored in

said first storage means which corresponds to the maximum tube voltage value after being changed at that time the maximum tube voltage value of said X-ray tube is changed; and

a first rewriting step at which first rewriting means of said X-ray tube control apparatus rewrites a warming-up program, stored in a memory section in a control apparatus that controls an operation of said X-ray tube, with said warming-up program extracted by said first extraction means via a telecommunications line.

[Claim 6]

An X-ray tube control method which remotely controls an X-ray tube with an X-ray tube control apparatus,

wherein a plurality of limit tube voltage control programs for stopping application of a tube voltage with a limit tube voltage value corresponding to a maximum tube voltage value of said X-ray tube as a threshold are stored in second storage means of said X-ray tube control apparatus beforehand according to the maximum tube voltage values, and comprising:

a second extraction step at which second extraction means of said X-ray tube control apparatus extracts said limit tube voltage control program from

said plurality of limit tube voltage control programs stored in said second storage means which sets a limit tube voltage value corresponding to the maximum tube voltage value after being changed as a threshold at that time the maximum tube voltage value of said X-ray tube is changed; and

a second rewriting step at which second rewriting means of said X-ray tube control apparatus rewrites a limit tube voltage control program, stored in a memory section in a control apparatus that controls an operation of said X-ray tube, with said limit tube voltage control program extracted by said second extraction means via a telecommunications line.

[Claim 7]

An X-ray tube control method which remotely controls an X-ray tube with an X-ray tube control apparatus,

wherein a plurality of limit tube current control programs for stopping application of a tube voltage with a limit tube current value corresponding to a maximum tube voltage value of said X-ray tube as a threshold are stored in third storage means of said X-ray tube control apparatus beforehand according to the maximum tube voltage values, and comprising:

a third extraction step at which third extraction

means of said X-ray tube control apparatus extracts said limit tube current control program from said plurality of limit tube current control programs stored in said third storage means which sets a limit tube current value corresponding to the maximum tube voltage value after being changed as a threshold at that time the maximum tube voltage value of said X-ray tube is changed; and

a third rewriting step at which third rewriting means of said X-ray tube control apparatus rewrites a limit tube current control program, stored in a memory section in a control apparatus that controls an operation of said X-ray tube, with said limit tube current control program extracted by said third extraction means via a telecommunications line.

[Claim 8]

An X-ray tube control method which remotely controls an X-ray tube with an X-ray tube control apparatus,

wherein a plurality of focus lens control programs for controlling a focus lens in such a way as to minimize a focal point when an electron beam hits a target of said X-ray tube with a maximum tube voltage applied to the target are stored in fourth storage means of said X-ray tube control apparatus according to the maximum tube voltage value beforehand, and comprising:

a fourth extraction step at which fourth extraction means of said X-ray tube control apparatus extracts said focus lens control program from said plurality of focus lens control programs stored in said fourth storage means which corresponds to the maximum tube voltage value after being changed at that time the maximum tube voltage value of said X-ray tube is changed; and

a fourth rewriting step at which fourth rewriting means of said X-ray tube control apparatus rewrites a focus lens control program, stored in a memory section in a control apparatus that controls an operation of said X-ray tube, with said focus lens control program extracted by said fourth extraction means via a telecommunications line.

[Detailed Description of the Invention]

[0001]

[Technical Field to which the Invention Pertains]

The present invention relates to an X-ray tube control apparatus and an X-ray tube control method.

[0002]

[Prior Art]

In case the maximum tube voltage of an X-ray tube is changed, an operational program of the X-ray tube has to be changed accordingly. Conventionally,

maintenance staff visited the place where the X-ray tube is installed to rewrite the operational program.

[0003]

[Problem to be Solved by the Invention]

However, the conventional method has a problem that heavy workload is required.

[0004]

The invention has been made to overcome the problem, and aims at providing an X-ray tube control apparatus and X-ray tube control method which allows the rewrite of the operational program with little workload.

[0005]

[Means for Solving the Problem]

To achieve the object, an X-ray tube control apparatus of the invention remotely controls an X-ray tube, and is characterized by having first storage means which stores a plurality of warming-up programs for warming up said X-ray tube to a maximum tube voltage, according to the maximum tube voltage values; first extraction means which extracts one from said plurality of warming-up programs stored in said first storage means which corresponds to the maximum tube voltage value after being changed at that time the maximum tube voltage value of said X-ray tube is changed; and first rewriting means which rewrites a warming-up program,

stored in a memory section in a control apparatus that controls an operation of said X-ray tube, with said warming-up program extracted by said first extraction means via a telecommunications line.

[0006]

In case the maximum tube voltage value of the X-ray tube is changed, the first extraction means extracts the warming-up program for warming up to a maximum tube voltage value after being changed from the first storage means. The first rewriting means rewrites the warming-up program with the one extracted by the first extraction means. Thus it becomes possible to rewrite the warming-up program by remote control via telecommunications line. Consequently, it becomes possible to rewrite the warming-up program with little workload.

[0007]

To achieve the object, the X-ray tube control apparatus of the invention is an X-ray tube control apparatus which remotely controls an X-ray tube, and is characterized by having second storage means which stores a plurality of limit tube voltage control programs for stopping application of a tube voltage with a limit tube voltage value corresponding to a maximum tube voltage value of the X-ray tube as a threshold,

according to the maximum tube voltage value; second extraction means which extracts the limit tube voltage control program from the plurality of limit tube voltage control programs stored in the second storage means which sets a limit tube voltage value corresponding to the maximum tube voltage value after being changed as a threshold at that time the maximum tube voltage value of the X-ray tube is changed; and second rewriting means which rewrites a limit tube voltage control program, stored in a memory section in a control apparatus that controls an operation of the X-ray tube, with the limit tube voltage control program extracted from the second extraction means via a telecommunications line.

[0008]

In case the maximum tube voltage value of the X-ray tube is changed, the second extraction means extracts the limit tube voltage control program which sets a limit tube voltage value corresponding to the maximum tube voltage value after being changed as a threshold. The second rewriting means rewrites the limit tube voltage control program with the one extracted by the second extraction means. Thus it becomes possible to rewrite the limit tube voltage control program by remote control via telecommunications line. Consequently, it becomes possible to rewrite the limit

tube voltage control program with little workload.

[0009]

To achieve the object, the X-ray tube control apparatus of the invention is an X-ray tube control apparatus which remotely controls an X-ray tube, and is characterized by having third storage means which stores a plurality of limit tube current control programs for stopping application of a tube voltage with a limit tube current value corresponding to a maximum tube voltage value of the X-ray tube as a threshold, according to the maximum tube voltage value; third extraction means which extracts the limit tube current control program from the plurality of limit tube current control programs stored in the third storage means which sets a limit tube current value corresponding to the maximum tube voltage value after being changed as a threshold at that time the maximum tube voltage value of the X-ray tube is changed; and third rewriting means which rewrites a limit tube current control program, stored in a memory section in a control apparatus that controls an operation of the X-ray tube, with the limit tube current control program extracted from the third extraction means via a telecommunications line.

[0010]

In case the maximum tube voltage value of the X-ray

tube is changed, the third extraction means extracts the limit tube current control program which sets a limit tube current value corresponding to the maximum tube voltage value after being changed as a threshold. The third rewriting means rewrites the limit tube current control program with the one extracted by the third extraction means. Thus it becomes possible to rewrite the limit tube current control program by remote control via telecommunications line. Consequently, it becomes possible to rewrite the limit tube current control program with little workload.

[0011]

To achieve the object, the X-ray tube control apparatus of the invention is an X-ray tube control apparatus which remotely controls an X-ray tube, and is characterized by having fourth storage means which stores a plurality of focus lens control programs for controlling a focus lens in such a way as to minimize a focal point when an electron beam hits a target of the X-ray tube with a maximum tube voltage applied to the target; fourth extraction means which extracts the focus lens control program from the plurality of focus lens control programs stored in the fourth storage means which corresponds to the maximum tube voltage value after being changed at that time the maximum tube voltage

value of the X-ray tube is changed; and fourth rewriting means which rewrites a focus lens control program, stored in a memory section in a control apparatus that controls an operation of the X-ray tube, with the focus lens control program extracted from the fourth extraction means via a telecommunications line.

[0012]

In case the maximum tube voltage value of the X-ray tube is changed, the forth extraction means extracts the focus lens control program corresponding to the maximum tube voltage value after being changed. The forth rewriting means rewrites the focus lens control program with the one extracted by the forth extraction means. Thus it becomes possible to rewrite the focus lens control program by remote control via telecommunications line. Consequently, it becomes possible to rewrite the focus lens control program with little workload.

[0013]

To achieve the object, an X-ray tube control method of the invention remotely controls an X-ray tube with an X-ray tube control apparatus, and is characterized by storing a plurality of warming-up programs for warming up the X-ray tube up to the maximum tube voltage value in first storage means of the X-ray tube control

apparatus beforehand according to the maximum tube voltage value, and including; a first extraction step at which first extraction means of the X-ray tube control apparatus extracts one from the plurality of warming-up programs stored in the first storage means which corresponds to the maximum tube voltage value after being changed at that time the maximum tube voltage value of the X-ray tube is changed; and a first rewriting step at which first rewriting means of the X-ray tube control apparatus rewrites a warming-up program, stored in a memory section in a control apparatus that controls an operation of the X-ray tube, with the warming-up program extracted from the first extraction means via a telecommunications line.

[0014]

In case the maximum tube voltage value of the X-ray tube is changed, in the first extraction step the first extraction means extracts the warming-up program for warming up to a maximum tube voltage value after being changed from the first storage means. In the first rewriting step the first rewriting means rewrites the warming-up program with the one extracted by the first extraction means. Thus it becomes possible to rewrite the warming-up program by remote control via telecommunications line. Consequently, it becomes

possible to rewrite the warming-up program with little workload.

[0015]

To achieve the object, the X-ray tube control method of the invention is an X-ray tube control method which remotely controls an X-ray tube with an X-ray tube control apparatus, and is characterized by storing a plurality of limit tube voltage control programs for stopping application of a tube voltage with a limit tube voltage value corresponding to a maximum tube voltage value of the X-ray tube as a threshold, in second storage means of the X-ray tube control apparatus beforehand according to the maximum tube voltage value, and including; a second extraction step at which second extraction means of the X-ray tube control apparatus extracts the limit tube voltage control program from the plurality of limit tube voltage control programs stored in the second storage means which sets a limit tube voltage value corresponding to the maximum tube voltage value after being changed as a threshold at that time the maximum tube voltage value of the X-ray tube is changed; and a second rewriting step at which second rewriting means of the X-ray tube control apparatus rewrites a limit tube voltage control program, stored in a memory section in a control apparatus that controls

an operation of the X-ray tube, with the limit tube voltage control program extracted from the second extraction means via a telecommunications line.

[0016]

In case the maximum tube voltage value of the X-ray tube is changed, in the second extraction step the second extraction means extracts the limit tube voltage control program which sets a limit tube voltage value corresponding to the maximum tube voltage value after being changed as a threshold. In the second rewriting step the second rewriting means rewrites the limit tube voltage control program with the one extracted by the second extraction means. Thus it becomes possible to rewrite the limit tube voltage control program by remote control via telecommunications line. Consequently, it becomes possible to rewrite the limit tube voltage control program with little workload.

[0017]

To achieve the object, the X-ray tube control method of the invention is an X-ray tube control method which remotely controls an X-ray tube with an X-ray tube control apparatus, and is characterized by storing a plurality of limit tube current control programs for stopping application of a tube voltage with a limit tube current value corresponding to a maximum tube voltage

value of the X-ray tube as a threshold, in third storage means of the X-ray tube control apparatus beforehand according to the maximum tube voltage value, and including; a third extraction step at which third extraction means of the X-ray tube control apparatus extracts the limit tube current control program from the plurality of limit tube current control programs stored in the third storage means which sets a limit tube current value corresponding to the maximum tube voltage value after being changed as a threshold at that time the maximum tube voltage value of the X-ray tube is changed; and a third rewriting step at which third rewriting means of the X-ray tube control apparatus rewrites a limit tube current control program, stored in a memory section in a control apparatus that controls an operation of the X-ray tube, with the limit tube current control program extracted from the third extraction means via a telecommunications line.

[0018]

In case the maximum tube voltage value of the X-ray tube is changed, in the third extraction step the third extraction means extracts the limit tube current control program which sets a limit tube current value corresponding to the maximum tube voltage value after being changed as a threshold. In the third rewriting

step the third rewriting means rewrites the limit tube current control program with the one extracted by the third extraction means. Thus it becomes possible to rewrite the limit tube current control program by remote control via telecommunications line. Consequently, it becomes possible to rewrite the limit tube current control program with little workload.

[0019]

To achieve the object, the X-ray tube control method of the invention is an X-ray tube control method which remotely controls an X-ray tube with an X-ray tube control apparatus, and is characterized by storing a plurality of focus lens control programs for controlling a focus lens in fourth storage means of the X-ray tube control apparatus beforehand in such a way as to minimize a focal point when an electron beam hits a target of the X-ray tube with a maximum tube voltage applied to the target, and including; a fourth extraction step at which fourth extraction means of the X-ray tube control apparatus extracts the focus lens control program from the plurality of focus lens control programs stored in the fourth storage means which corresponds to the maximum tube voltage value after being changed at that time the maximum tube voltage value of the X-ray tube is changed; and a fourth rewriting step at which fourth

rewriting means of the X-ray tube control apparatus rewrites a focus lens control program, stored in a memory section in a control apparatus that controls an operation of the X-ray tube, with the focus lens control program extracted from the fourth extraction means via a telecommunications line.

[0020]

In case the maximum tube voltage value of the X-ray tube is changed, in the fourth extraction step the forth extraction means extracts the focus lens control program corresponding to the maximum tube voltage value after being changed. In the fourth rewriting step the forth rewriting means rewrites the focus lens control program with the one extracted by the forth extraction means. Thus it becomes possible to rewrite the focus lens control program by remote control via telecommunications line. Consequently, it becomes possible to rewrite the focus lens control program with little workload.

[0021]

[Embodiments of the Invention]

Preferred embodiments of an X-ray tube control apparatus and an X-ray tube control method according to the invention will be described in detail below with reference to the accompanying drawings.

[0022]

First, the structure and operation of an X-ray tube 1 which is managed by an X-ray tube control apparatus 3 according to the embodiment will be described. Fig. 1 is an exemplary diagram (cross-sectional view) showing the structure of the X-ray tube 1. As shown in Fig. 1, the X-ray tube 1 is sealed in vacuum by the outer casing comprised of a metal enclosure 11, which is kept at the ground potential, an insulator stem 12 and a beryllium window 13 which passes X-rays.

[0023]

The X-ray tube 1 has a cathode 110 which emits thermions when heated by a heater, a first focus grid electrode 120 and a second grid electrode 130, which accelerate and converge the thermions, a third grid electrode 140 which is kept at the same potential (ground potential) as that of the metal enclosure 11, and a tungsten target 150 which generates X-rays when hit by the thermions. The first focus grid electrode 120 has a function of pushing the thermions back to the filament side when applied with a negative voltage. The second grid electrode 130 has a function of pulling the thermions toward the target side when applied with a positive voltage. The first focus grid electrode 120 and the second grid electrode 130, together with the

third grid electrode 140, also have a function as an electrostatic lens (focus lens) to converge an electron beam. The first focus grid electrode 120, the second grid electrode 130 and the third grid electrode 140 are arranged in that order from the cathode 110 to the target 150, and the first focus grid electrode 120, the second grid electrode 130 and the third grid electrode 140 respectively have an opening 120a, an opening 130a and an opening 140a in their centers for passing the thermions.

[0024]

The X-ray tube 1 has a power supply 15 including a high-voltage generating circuit for applying a positive high voltage to the target 150.

[0025]

The X-ray tube 1 is controlled by an X-ray tube controller 2 connected to the X-ray tube 1 by a control cable 16.

[0026]

When the main power supply of the X-ray tube 1 is on, the cathode 110 emits thermions as it is heated by a heater. The X-ray tube 1 starts warming up to increase the tube voltage to the maximum tube voltage value step by step and increase the tube current value to the maximum tube current value (the tube current value to minimize

the focal diameter under the maximum tube voltage value) step by step. As warming-up ends, a negative cutoff voltage is applied to the first focus grid electrode 120, stopping the tube current.

[0027]

When the X-ray irradiation switch of the X-ray tube 1 is on, the voltage which is applied to the first focus grid electrode 120 rises from the cutoff voltage to an operation voltage, and the thermions emitted from the cathode 110 are pulled to the second grid electrode 130, which has a higher potential than the cathode 110 does, and pass through the opening 120a of the first focus grid electrode 120. Further, the thermions pass through the opening 130a of the second grid electrode 130 and the opening 140a of the third grid electrode 140 while being accelerated by the tube voltage applied to the target 150, and becomes an electron beam directing toward the target 150 applied with the positive high voltage. At the time of passing the opening 120a, the opening 130a and the opening 140a, the electron beam contracts its beam diameter by an electric field formed by the first to third grid electrodes, the cathode 110 and the target 150. When the electron beam which is converged by the electric field hits the target 150, the target 150 generates X-rays. The X-rays pass through the beryllium

window 13 and exit the X-ray tube 1.

[0028]

The focal diameter when an electron beam hits the target 150 varies according to the strength of the electrostatic lens or the tube voltage, and the voltage applied to the first focus grid electrode 120 and the voltage applied to the second grid electrode 130. The voltages applied to the first focus grid electrode 120 and the second grid electrode 130 are controlled in such a way that the focal diameter under the maximum tube voltage is minimized. The maximum tube current value is determined by the thus controlled voltage values of the first focus grid electrode 120 and the second grid electrode 130.

[0029]

Next, the functional structure of the X-ray tube management system to which the X-ray tube control apparatus 3 is adapted will be described. Fig. 2 is a diagram for explaining the X-ray tube management system to which the X-ray tube control apparatus 3 is adapted. As shown in Fig. 2, the X-ray tube management system has the X-ray tube 1, the X-ray tube controller 2 and the X-ray tube control apparatus 3. The X-ray tube 1 and the X-ray tube controller 2 are set at the place of a user while the X-ray tube control apparatus 3 is set at

the place of a customer engineer for the X-ray tube, and both are connected via a telecommunications line such as the Internet.

[0030]

The X-ray tube controller 2 has a control section 22, a memory section 24 and a communications section 26 which functions as a rewriting section. The control section 22 has functions of reading an operation program 240 stored in the memory section 24 and operating the individual sections of the X-ray tube 1 according to the operation program 240.

[0031]

The operation program 240 for the X-ray tube 1 is stored in the memory section 24. Fig. 3 is a structural diagram of the operation program 240 stored in the memory section 24. The operation program 240 includes a maximum tube voltage value setting module 240a, which sets the maximum tube voltage value of the X-ray tube 1 (that is set to 130 kV at the time of shipment of the X-ray tube 1), a warming-up module 240b, which warms up the X-ray tube 1 to the maximum tube voltage value, a limit tube voltage control module 240c, which stops application of the tube voltage, with the limit tube voltage value corresponding to the maximum tube voltage value of the X-ray tube 1 (the limit tube voltage value

is set to a voltage value higher than the maximum tube voltage value by approximately 30 kV) being a threshold, a limit tube current control module 240c, which stops application of the tube voltage, with the limit tube current value corresponding to the maximum tube voltage value of the X-ray tube 1 (the limit tube current value is set to a current value higher than the maximum tube current value (the tube current value that minimizes the focal diameter under the maximum tube voltage value) by approximately 50 μA) being a threshold, and a focus grid electrode control module 240e, which controls the voltages to be applied to the first focus grid electrode 120 and the second grid electrode 130 in such a way as to minimize the focal diameter with the maximum tube voltage applied to the target 150.

[0032]

The X-ray tube control apparatus 3 has storage sections 32a-e, an extraction section 34 and a communications section (input, transmission) 36. Fig. 4 is a diagram showing the modules of the operation program 240 stored in the storage sections 32a-e. The maximum tube voltage value setting module 240a (maximum tube voltage value: 130 kV, 120 kV, 110 kV, 100 kV, ...), which corresponds to the maximum tube voltage that becomes lower from 130 kV by 10 kV at that time, is stored

in the storage section 32a. The warming-up module 240b (maximum tube voltage value: 130 kV, 120 kV, 110 kV, 100 kV, ...), which corresponds to the maximum tube voltage that becomes lower from 130 kV by 10 kV at that time, is stored in the storage section 32b. The limit tube voltage control module 240c (limit tube voltage value: 150 kV, 140 kV, 135 kV, 130 kV, ...), which corresponds to the maximum tube voltage that becomes lower from 130 kV by 10 kV at that time, is stored in the storage section 32c. The limit tube current control module 240d (limit tube current value: 360 μA, 300 μA, 270 μA, 240 μA, ...), which corresponds to the maximum tube voltage that becomes lower from 130 kV by 10 kV at that time, is stored in the storage section 32d. The focus grid electrode control module 240e (maximum tube voltage value: 130 kV, 120 kV, 110 kV, 100 kV, ...), which corresponds to the maximum tube voltage that becomes lower from 130 kV by 10 kV at that time, is stored in the storage section 32e.

[0033]

The extraction section 34 has a function of extracting one corresponding to the changed maximum tube voltage value from the modules of the operation program 240 stored in the storage sections 32a-e when the maximum tube voltage value of the X-ray tube 1 is changed.

[0034]

The communications section 36 has a function of sending the operation program 240, comprised of each module extracted by the extraction section 34, to the X-ray tube controller 2 and overwriting it in the memory section 24.

[0035]

Next, a description will be given of the operation of the X-ray tube control apparatus 3 to rewrite the operation program 240 at the time the maximum tube voltage value of the X-ray tube 1 is changed.

[0036]

A customer engineer changes the maximum tube voltage value of the X-ray tube 1 according to a request from a user by using the X-ray tube control apparatus. The extraction section 34 of the X-ray tube control apparatus extracts the maximum tube voltage value setting module 240a corresponding to the maximum tube voltage value to be changed from the storage section 32a. At the same time, the extraction section 34 extracts the warming-up module 240b, the limit tube voltage control module 240c, the limit tube current control module 240d and the focus grid electrode control module 240e which correspond to the maximum tube voltage value to be changed from the storage sections 32b-e, respectively.

[0037]

The communications section 36 sends the operation program 240, comprised of the maximum tube voltage value setting module 240a, the warming-up module 240b, the limit tube voltage control module 240c, the limit tube current control module 240d and the focus grid electrode control module 240e extracted by the extraction section 34, to the X-ray tube controller 2 via the telecommunications line, and overwrites the operation program 240 stored in the memory section 24 with it.

[0038]

Effect of the operation by the above described X-Ray tube control apparatus 3 rewriting the operational program 240 is explained.

[0039]

In case the maximum tube voltage value of the X-ray tube 1 is increased, the warming-up program has to be rewritten so as to warm up to a maximum tube voltage value after being changed. And, in case the maximum tube voltage value of the X-ray tube 1 is decreased, by rewriting the warming-up program so as to warm up to a maximum tube voltage value after being changed, warming-up process can be simplified. By above described operation of the X-ray tube control apparatus 3, it becomes possible to rewrite the warming-up program by remote control via telecommunications line.

Consequently, it becomes possible to rewrite the operational program with little workload.

[0040]

In case the maximum tube voltage value of the X-ray tube 1 is increased, the limit tube voltage control program has to be rewritten so that the limit tube voltage value increases to the value corresponding to a maximum tube voltage value after being changed. And, in case the maximum tube voltage value of the X-ray tube 1 is decreased, by rewriting the limit tube voltage control program so that the limit tube voltage value increases to the value corresponding to a maximum tube voltage value after being changed, it can be possible to prevent the discharge phenomenon from being occurring more securely. By above described operation of the X-ray tube control apparatus 3, it becomes possible to rewrite the limit tube voltage control program by remote control via telecommunications line. Consequently, it becomes possible to rewrite the operational program with little workload.

[0041]

In case the maximum tube voltage value of the X-ray tube 1 is increased, the limit tube current control program has to be rewritten so that the limit tube current value increases to the value corresponding to a maximum

tube voltage value after being changed. And, in case the maximum tube voltage value of the X-ray tube 1 is decreased, by rewriting the limit tube current control program so that the limit tube current value increases to the value corresponding to a maximum tube voltage value after being changed, it can be possible to prevent the discharge phenomenon from being occurring more securely. By above described operation of the X-ray tube control apparatus 3, it becomes possible to rewrite the limit tube current control program by remote control via telecommunications line. Consequently, it becomes possible to rewrite the operational program with little workload.

[0042]

In case the maximum tube voltage value of the X-ray tube 1 is changed, it is preferable to rewrite the focus lens control program so that focal diameter of the electron beam is minimized at the time when the X-ray tube 1 is operated at the maximum tube voltage value after being changed. By above described operation of the X-ray tube control apparatus 3, it becomes possible to rewrite the focus lens control program by remote control via telecommunications line. Consequently, it becomes possible to rewrite the operational program with little workload.

[0043]

The control of the X-ray tube 1 according to the above described process in the X-ray tube control system is also the embodiment of the X-ray tube control method of the present invention. By the embodiment of the X-ray tube control method, the same operation and effect as in the control of the X-ray tube 1 in the above described X-ray tube control system can be achieved.

[0044]

[Effects of the Invention]

As explained above, according to the X-ray tube control apparatus and X-ray tube control method of the present invention it can be possible to rewrite the operational program with little workload.

[Brief Description of the Drawings]

[Fig. 1]

Fig. 1 is an exemplary diagram (cross-sectional view) showing the structure of an X-ray tube 1.

[Fig. 2]

Fig. 2 is a diagram for explaining an X-ray tube management system according to a first embodiment.

[Fig. 3]

Fig. 3 is a structural diagram of an operation program 240 stored in a memory section 24.

[Fig. 4]

Fig. 4 is a diagram showing modules of the operation program 240 stored in storage sections 32a-e.

[Fig. 5]

Fig. 5 is a diagram showing an example of the warming-up pattern when the maximum tube voltage is 130 kV.

[Explanation of Reference Numerals]

1: X-ray tube

11: metal enclosure

12: insulator stem

13: beryllium window

15: power supply

16: control cable

110: cathode

120: first focus grid electrode

130: second grid electrode

140: third grid electrode

120a, 130a, 140a: opening

150: tungsten target

2: X-ray tube controller

22: control section

24: memory section

26: communications section

3: X-ray tube control apparatus

32a-e: storage section

34: extraction section

36: rewriting section

38: communication section

240: operational program

240a: maximum tube voltage value setting module

240b: warming-up module

240c: limit tube voltage control module

240d: limit tube current control module

240e: focus grid electrode control module

[Document Name] ABSTRACT

[Abstract]

[Problem]

Making it possible to rewrite the operational program with little workload.

[Means of Solution]

A maximum tube voltage value setting module 240a, a warming-up module 240b, a limit tube voltage control module 240c, a limit tube current control module 240d and a focus grid electrode control module 240e of an operation program 240 which respectively correspond to different maximum tube voltage values are stored in storage sections 32a-e of an X-ray tube control apparatus 3. When the maximum tube voltage value of an X-ray tube 1 is changed, an extraction section 34 extracts each module of the operation program 240 which corresponds to the maximum tube voltage value after being changed from the storage sections 32a-e. A communications section 36 sends the operation program 240 comprised of each extracted module to an X-ray tube controller 2 and overwrites it in a memory section 24.

[Selected Drawing]

Fig. 2

PATENT OFFICE

JAPANESE GOVERNMENT

This is to certify that the annexed is a true copy of the following application as filed with this Office.

Date of Application:

Application Number: Japanese Patent Application No.103881/2002

Commissioner,

Patent Office (Seal)

Fig.1

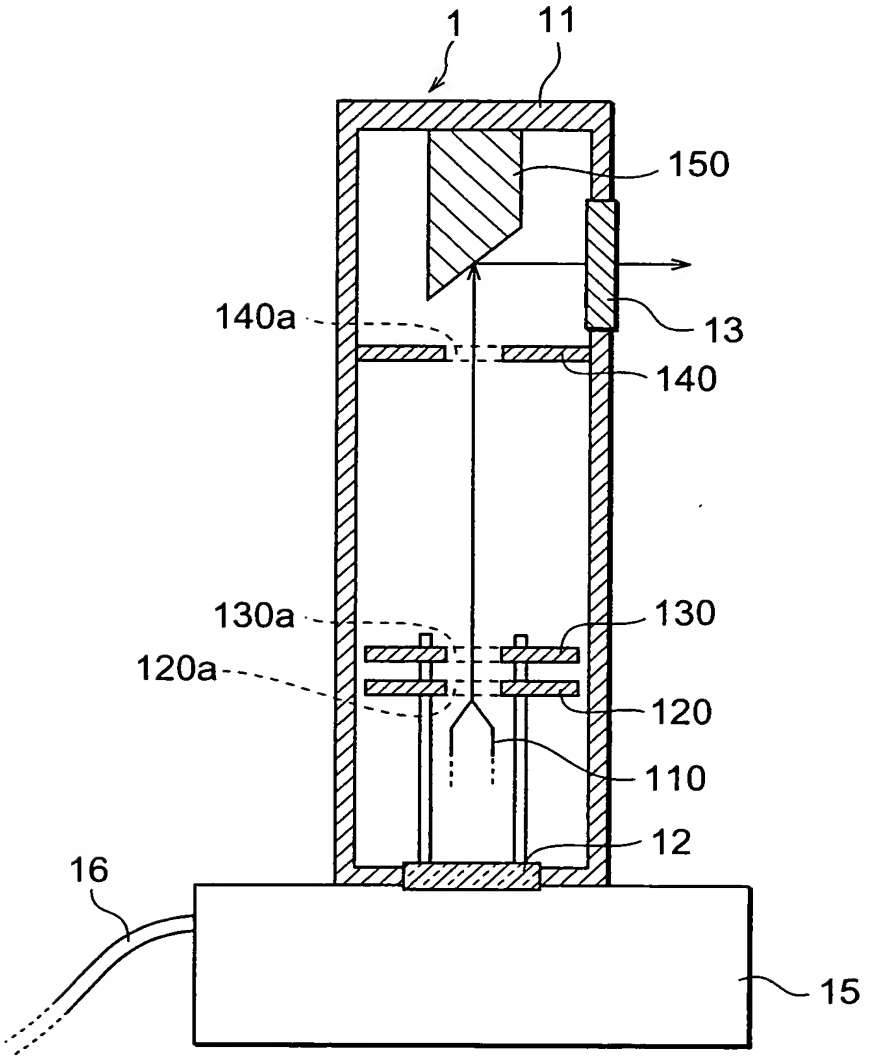

Fig.2

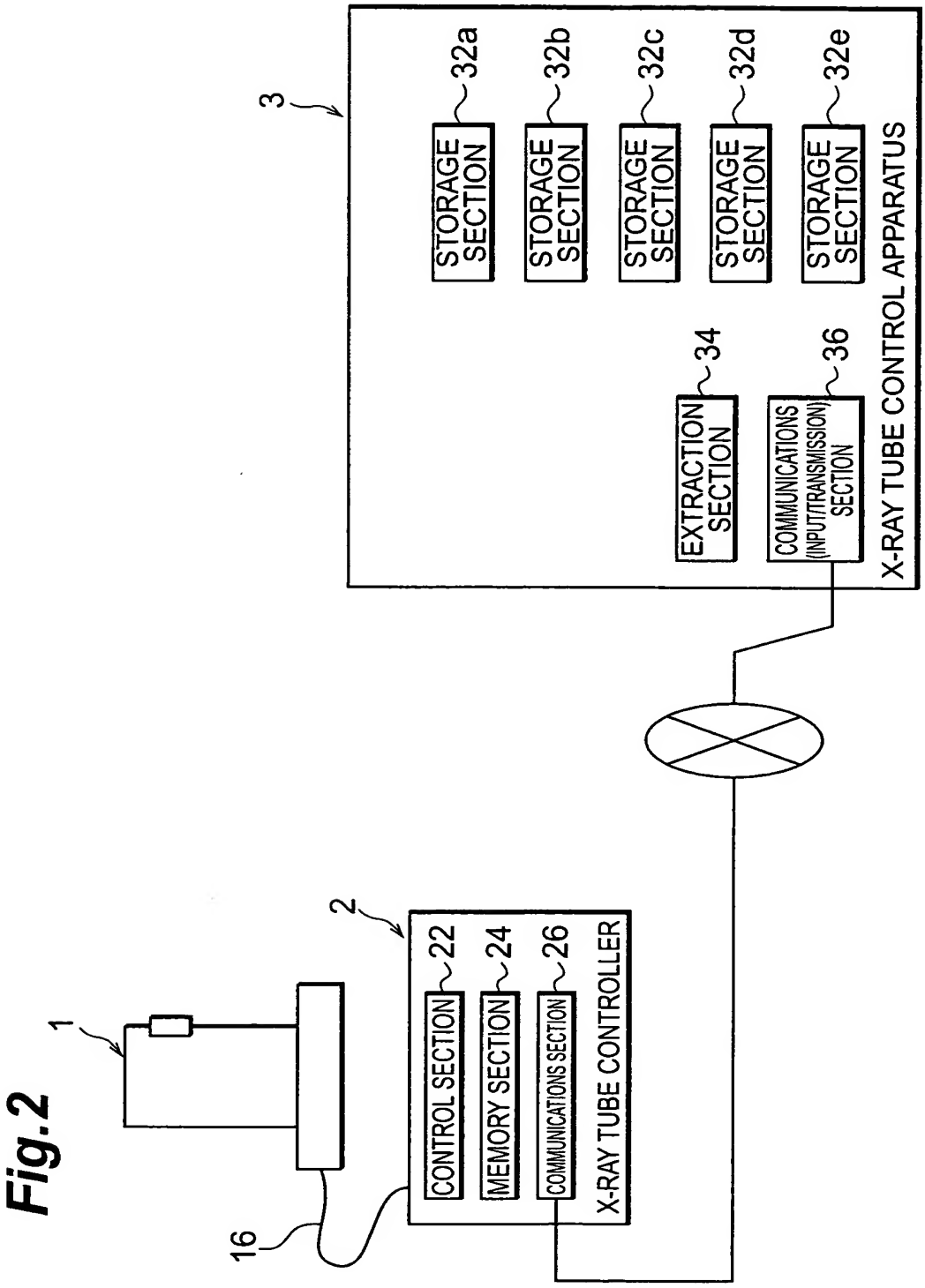
1
2
3
16
CONTROL SECTION
22
MEMORY SECTION
24
COMMUNICATIONS SECTION
26
X-RAY TUBE CONTROLLER
STORAGE SECTION
32a
STORAGE SECTION
32b
STORAGE SECTION
32c
STORAGE SECTION
32d
STORAGE SECTION
32e
EXTRACTION SECTION
34
COMMUNICATIONS (INPUT/TRANSMISSION) SECTION
36
X-RAY TUBE CONTROL APPARATUS

Fig.3

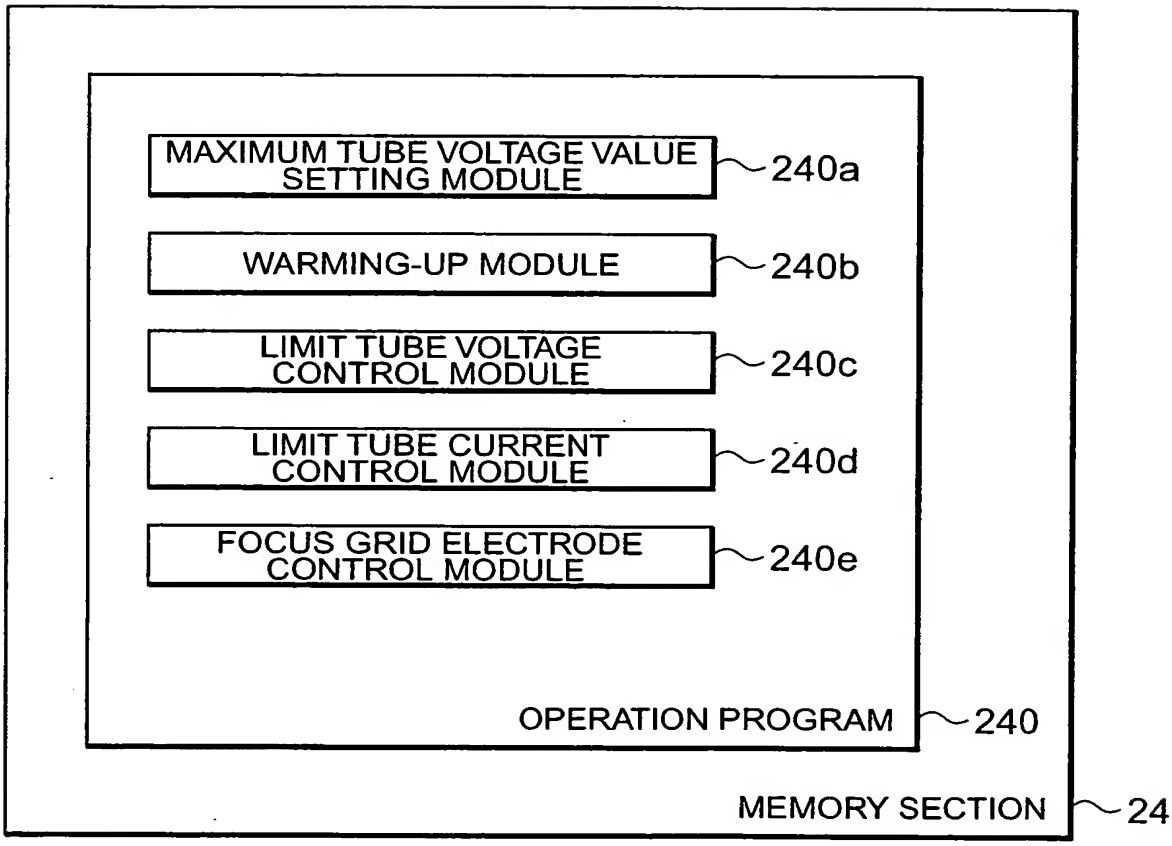
MAXIMUM TUBE VOLTAGE VALUE SETTING MODULE
240a
WARMING-UP MODULE
240b
LIMIT TUBE VOLTAGE CONTROL MODULE
240c
LIMIT TUBE CURRENT CONTROL MODULE
240d
FOCUS GRID ELECTRODE CONTROL MODULE
240e
OPERATION PROGRAM
240
MEMORY SECTION
24

Fig.4

MAXIMUM TUBE VOLTAGE VALUE	STORAGE SECTION 32a	STORAGE SECTION 32b	STORAGE SECTION 32c	STORAGE SECTION 32d	STORAGE SECTION 32e
130kV	MAXIMUM TUBE VOLTAGE VALUE SETTING MODULE (130 kV)	WARMING-UP MODULE (FOR 130 kV)	LIMIT TUBE VOLTAGE CONTROL MODULE (150 kV)	LIMIT TUBE CURRENT CONTROL MODULE (360 μA)	FOCUS GRID ELECTRODE CONTROL MODULE (V_{130}[V])
120kV	MAXIMUM TUBE VOLTAGE VALUE SETTING MODULE (120 kV)	WARMING-UP MODULE (FOR 120 kV)	LIMIT TUBE VOLTAGE CONTROL MODULE (140 kV)	LIMIT TUBE CURRENT CONTROL MODULE (300 μA)	FOCUS GRID ELECTRODE CONTROL MODULE (V_{120}[V])
110kV	MAXIMUM TUBE VOLTAGE VALUE SETTING MODULE (110 kV)	WARMING-UP MODULE (FOR 110 kV)	LIMIT TUBE VOLTAGE CONTROL MODULE (135 kV)	LIMIT TUBE CURRENT CONTROL MODULE (270 μA)	FOCUS GRID ELECTRODE CONTROL MODULE (V_{110}[V])
100kV	MAXIMUM TUBE VOLTAGE VALUE SETTING MODULE (100 kV)	WARMING-UP MODULE (FOR 100 kV)	LIMIT TUBE VOLTAGE CONTROL MODULE (130 kV)	LIMIT TUBE CURRENT CONTROL MODULE (240 μA)	FOCUS GRID ELECTRODE CONTROL MODULE (V_{100}[V])
⋮	⋮	⋮	⋮	⋮	⋮

FP03-0059-00

Fig.5

240

MAXIMUM TUBE VOLTAGE: 130 kV/MAXIMUM TUBE CURRENT: 300 μA					
LIMIT TUBE VOLTAGE: 150 kV					
LIMIT TUBE CURRENT: 360 μA					
FOCUS GRID VOLTAGE: V_{130}[V]					
STEP	TUBE VOLTAGE (kV)	TUBE CURRENT (μA)	WARMING-UP TIME (min)		
			8 HOURS TO ONE MONTH AFTER OFF	ONE MONTH TO THREE MONTHS AFTER OFF	THREE MONTHS OR MORE AFTER OFF
1	27	0	1	5	10
2	54	30	1	5	30
3	81	90	3	6	20
4	108	150	3	7	30
5	121	220	3	7	20
6	130	300	4	10	10
			TOTAL 15(min)	TOTAL 40(min)	TOTAL 120(min)